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CONTRIBUTIONS FROM THE HARVARD MINERALOGICAL MUSEUM. — XII.

1. BABINGTONITE FROM SOMERVILLE, MASS.

2. BABINGTONITE FROM ATHOL, MASS.

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Presented by J. E. Wolff, October 8, 1902. Received October 8, 1902.

BABINGTONITE FROM SOMERVILLE, MASS.

Occurrence and Paragenesis.

THE occurrence of babingtonite at Somerville has long been recorded, but no adequate description of it seems to have been published. We first find mention of it in a description by Teschemacher * of the minerals of the Charlestown sienite quarry, where it is called "hornblende in the form of oblique rhombic prism with modifications c, k, l; crystals are small and black on white prehnite."

In Alger's Phillip's Mineralogy, 1844, p. 79, it is stated on the authority of Professor Nuttall that babingtonite occurs at Charlestown and that this is the only American locality. No description of the mineral by Nuttall has been found, and Alger probably had the information privately from Nuttall. This statement was copied in Brooke and Miller's Mineralogy (1852), but appears never to have found its way into the American text-books, the only further mention of it being in Dana's System (1892), where, although not referred to in the text, the mineral is listed in the Catalogue of Localities, p. 1059, as occurring at Somerville.

The babingtonite occurs in veins and pockets composed chiefly of prehnite, which traverse a large dyke of diabase.† This dyke is well exposed in an old quarry, recently abandoned, on Granite Street, Somerville, formerly known as the Milk Row quarry, Charlestown, and it is from this quarry that the material here described has all been obtained. The mineral is not abundant, and it was only after several years of collecting in the fresh quarry openings that sufficient material for analysis and adequate crystallographic study was accumulated. In addition to the material now in the Harvard Mineral Cabinet, several fine specimens from the same locality were placed at our disposal by Mr. H. I. Johnson.

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* Proc. Boston Soc. N. H., June, 1839, in Am. J. Sci., XXXVIII., 1840, p. 194.

† For a description of this rock, which is called sienite in all of the above references, see Wadsworth, Proc. Bos. Soc. N. H., XIX. (1879), p. 223, and Jaggar, Am. Geol., XXI. (1898), pp. 203-213.

The minerals commonly associated with the babingtonite are prehnite, quartz, epidote, pyrite, chlorite, feldspar, and calcite. Other minerals reported from the locality are laumontite, stilbite, chabazite, melanolite (known only from here and a doubtful species), and chalcodite.

Prehnite is much the most abundant mineral in the veins, always lining the walls and often forming the whole vein-filling. It varies in color from pure white to quite a deep green, which often fades on exposure to light. It has the characteristic drusy reniform surface of prehnite, the crystals rarely individual. Occasionally the crystals composing the globular or barrel-shaped groups are sufficiently distinct to show that they are tabular parallel to c (001) with edges formed by m (110) and sometimes also a (100). A single specimen showed a number of lath-shaped crystals attached by one end to massive prehnite, on which only the three pinacoids were present. Prehnite also forms fine-grained granular masses of dull white color.

Quartz is sparingly present, generally as small pellucid crystals implanted on prehnite. In one specimen the quartz is in the form of capillary crystals stretching from wall to wall of small cavities in massive prehnite. Most of the crystals are combinations of the common forms m $(10\bar{1}0)$, r $(10\bar{1}1)$, and z $(0\bar{1}11)$ but a few were observed and measured of more complex character on which the following less common forms were found: d $(10\bar{1}2)$, π $(01\bar{1}2)$, G $(13.0.\overline{13}.9)$, s_1 $(\bar{1}\bar{1}21)$, $(9\bar{2}\bar{7}2)$, y $(41\bar{5}1)$. These forms were present as narrow truncations of edges of the common forms. The alternate edges of the unit prism were also truncated by planes of a trigonal prism, apparently etch faces, which gave distinct readings at variable angles not corresponding to any known form of quartz but near $(10.1.\overline{11}.0)$.

Epidote occurs quite commonly in minute yellowish-green needles implanted on prehnite or coating and intimately intergrown with babingtonite and quartz. The crystals are not measurable.

Pyrite is found occasionally in clusters of minute crystals resting on prehnite or babingtonite. The crystals are too minute and too poorly developed to permit of measurement, but they appear to be dominated by the cube.

Chlorite is not common with the babingtonite, but is apt to occur intermixed with the massive form of the prehnite.

Feldspar is found with prehnite and babingtonite in a few specimens, in the form of small imperfect pinkish crystals. They are similar in appearance to the pinkish labradorite of the enclosing diabase and were not further determined. This mineral is found only in certain pockets of oval form entirely enclosed in the diabase. The dyke at this point contains many inclusions of various rocks, and it is probable that these pockets represent inclusions in which the original material has been almost wholly replaced by prehnite and calcite. Wadsworth* found pseudomorphs of prehnite after feldspar here, which fact to some extent strengthens this conclusion, based chiefly upon the form of the pockets.

Calcite occurs in both veins and pockets as the last substance deposited, filling up all the interstices of the other minerals. It is white and glassy, often in large individuals, but never, so far as observed, in developed crystals. Near the surface of the veins the calcite has generally been removed by solution, but away from the zone of weathering it seems always to be present, and all the finer specimens of prehnite and babingtonite were obtained by dissolving away the infilling of calcite with dilute acid.

Of the remaining minerals recorded above from the locality one only, chabazite, has been seen by the authors. It occurs in well-formed twin rhombohedrons, pure white in color, implanted on a specimen of massive prehnite. The specimen was not collected by us and this mineral has not been found at the locality for some years.

The babingtonite is usually in distinct crystals implanted upon, and in rare instances wholly embedded in, prehnite. The crystals are often but slightly attached to the prehnite, and are therefore not infrequently completely bounded by crystal planes. They are generally small, rarely exceeding 2 or 3 mm. in greatest dimension; but a few larger crystals were obtained, the largest measuring 1.5 × 1 ×.4 cm. The complete detached crystal shown in figure 3 is 1 ×.7 ×.2 cm. and is perhaps the largest perfect crystal preserved from the locality. Granular aggregates of babingtonite are also found embedded in prehnite, composed sometimes of fine grains and again of individuals so large that cleavage surfaces of several square centimeters' area may be observed.

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* Loc. cit., p. 223.

The babingtonite is black in color and of a brilliant vitreous lustre. It is, however, very subject to decay, and when the protecting calcite has been removed and the babingtonite exposed to the weather it becomes dull and gradually alters to limonite, of which complete pseudomorphs are frequently found. The decay is most active along the incipient cleavage cracks, and crystals which appear on the surface fresh and sound are often found on being broken to be permeated throughout by limonite films. This character proved to be so universal in the larger crystals that all attempts to prepare plates from them for the study of the optical properties were unsuccessful.

Crystallography.

Twenty of the smaller crystals were measured and the following forms determined, those marked with an asterisk being new to the mineral; c (001), b (010), a (100), h (110), g $(2\bar{1}0)$, f $(3\bar{2}0)$, k *$(1\bar{1}0)$, u *(054), o (011), v *(035), w *(025), s $(0\bar{1}1)$, d (101), x *(305), y *(205), n *$(\bar{1}01)$, p *(111), t *(112), i *$(\bar{1}\bar{1}2)$.

The faces of the prism zone are generally deeply striated parallel to the prism axis, and the basal plane is often curved or faceted. It was found too that even where all the faces were plane there was often a lack of parallelism in opposite faces, especially those of the prism zone, which made the accurate adjustment on the goniometer difficult; and for this reason many of the crystals were measured both by the two-circle method and by adjusting one plane in polar position and determining the interfacial angles of the others to it. Both groups of measurements are presented in the tables which follow, and the wide range of values for many of the angles gives a measure of the irregularities to which the crystals are subject.

The position here adopted for babingtonite is that of Dauber, and his elements have been used for the calculation of the table of angles.*

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* The choice of this position rather than the one taken by Dana and Hintze, which is designed to bring out the similarity in form between babingtonite and the monoclinic pyroxenes, may be justified on several grounds. The dominant habit of the crystals, as may be seen from the figures, is prismatic in the direction of Dauber's prism zone, so that this is the natural position in which to orient them and very much simplifies the adjustment and measurement. In Dana's position this zone is made a pyramid zone. Furthermore Dauber's position gives much simpler symbols for the forms, as may be seen in the accompanying table. The position of Goldschmidt (Winkeltabellen) gives symbols as simple, but, like Dana's,

Dauber's elements were based on a very large number of measurements on crystals of babingtonite from Arendal. His values for many angles show a considerable range, up to a degree or more, on either side of the mean value. Our measurements of interfacial angles, as shown in Table I, show a like range, and the means agree on the whole so closely with Dauber's calculated values that it was deemed best not to attempt to establish new elements for the Somerville mineral. Moreover the co-ordinate angles calculated from them for the two-circle readings agree closely with the measured angles, as may be seen in Table II.

The forms may be characterized as follows.

In the prism zone a (100) and b (010) are always present, generally brilliant and free from striations, but often slightly curved.

h (110) is generally present as a very narrow, brilliant face.

g $(2\bar{1}0)$ and f $(3\bar{2}0)$ are generally both present, most often in oscillatory combination as a broad, gently curved surface striated vertically — a very characteristic feature of crystals from this locality. When f is absent g is less deeply striated, but is rarely perfectly plane. Notwithstanding their striation, both faces give good reflections.

k $(1\bar{1}0)$. A number of faint reflections were observed in the vicinity of the faces f and g, but the only one which was observed more than once and was assignable to a definite form was the new form k, which was found with both faces on one crystal and a single face on another. The faces were narrow and reflection poor, but the form seems assured.

c (001) is always present, generally plane, but sometimes faintly striated parallel to intersection with s and o, or faceted.

The domes o (011), s $(0\bar{1}1)$, and d (101) are always bright faces giving good images. They are all three present on many crystals, s is never lacking, and d is more frequently absent than o. They vary much

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is unsatisfactory in not making the dominant and most easily recognized zone the prism zone.

Dauber.	Dana.	Goldschmidt.	Dauber.	Dana.	Goldschmidt.
c (001)	M $(1\bar{1}0)$	c (010)	n $(\bar{1}01)$	$(\bar{2}21)$	(011)
b (010)	m (110)	b (100)	u (054)	(010)	(540)
a (100)	c (001)	a (001)	v (035)	$(4\bar{1}0)$	(350)
h (110)	h (221)	q (101)	w (025)	$(7\bar{3}0)$	(250)
g $(2\bar{1}0)$	g $(11\bar{1})$	r $(\bar{1}02)$	x (305)	$(10.\overline{10}.3)$	(053)
f $(3\bar{2}0)$	f $(44\bar{3})$	l $(\bar{2}03)$	y (205)	(551)	(052)
k $(1\bar{1}0)$	(221)	$(\bar{1}01)$	p (111)	(401)	(111)
o (011)	a (100)	o (110)	t (112)	$(6\bar{2}1)$	(121)
s $(0\bar{1}1)$	b (010)	s $(1\bar{1}0)$	i $(\bar{1}\bar{1}2)$	$(\bar{2}61)$	$(1\bar{2}1)$
d (101)	d (221)	δ (011)			

TABLE I.

	Angle calculated.	Measured (Mean).	Limits.	No. of Readings.
	° ′	° ′	° ′ ° ′	
ab	67 48	67 54	66 49– 68 40	15
ab′	112 12	112 04	111 13–112 47	13
ac	87 28	87 01	86 44– 87 28	6
ac′	92 32	92 45	92 18– 93 15	5
af	59 36	59 26	59 03– 59 48	4
af′	120 24	120 33	120 12–120 57	4
ag	47 33	47 15	46 59– 47 22	4
ag′	132 27	132 42	132 38–132 50	3
ah	43 05	43 37	43 12– 44 30	8
ah′	136 55	136 20	135 45–136 49	6
fg	12 00	12 58	11 42– 13 51	6
f′h	77 18	76 43	75 49– 77 32	6
g′h	89 18	89 04	88 23– 89 34	6
bc	92 36	91 48	91 26– 92 20	8
bc′	87 24	87 43	87 17– 88 26	6
bf	52 36	52 37	51 55– 53 14	6
bf′	127 24	127 07	126 46–128 01	5
bg	64 39	64 48	64 26– 64 59	4
bg′	115 21	115 12	115 04–115 35	6
bh	24 43	24 15	23 01– 25 07	11
bh′	155 17	155 43	155 16–156 43	11
bo	47 23	46 46	46 25– 47 18	6
bo′	132 37	132 42		1
bs	44 40	44 48	44 20– 45 17	2
bs′	135 20	134 53	134 03–135 58	6
cg	85 27	84 59	84 40– 85 18	5
cg′	94 33	94 37	94 08– 95 13	5
co	45 13	45 10	44 19– 46 13	11
co′	134 47	134 43	134 33–134 53	2
cs	42 44	43 08	42 33– 44 00	6
cs′	137 16	136 51	136 13–137 33	3
cd	29 55	29 38	29 16– 29 58	9

in size from being dominant terminating planes to narrow truncations of the edges between c and faces of the prism zone.

The remaining forms observed are all new and vary much in quality. Of the domes, n ($\bar{1}01$) is well established, having been observed on six

TABLE II.

ELEMENTS.

$p_0 = 0.59098$	$\lambda = 92° 36'$	$a = 1.635$	$a_0 = 1.8257$	$\alpha = 86° 09'$	$x_0 = 0.0662$	$d = 0.0803$
$q_0 = 0.9662$	$\mu = 87° 28'$	$b = 1.$	$b_0 = 1.1167$	$\beta = 93° 48'$	$y_0 = \bar{0}.0454$	$\delta = 124° 24'$
$r_0 = 1.$	$\nu = 67° 48'$	$c = 0.8955$	$c_0 = 1.$	$\gamma = 112° 22'$	$h = 0.9968$	

	Calculated.		Measured (Mean).		Limits.	Limits.	No.	Quality.
	ϕ	ρ	ϕ	ρ	ϕ	ρ		
	° ′	° ′	° ′	° ′	° ′ ° ′	° ′ ° ′		
c 001	124 24	4 36	119 37	4 53½	116 02-123 34	4 12- 5 00	8	very good
b 010	00 00	90 00	00 00	90 00	. . .	. . .	20	“ “
a 100	67 48	90 00	67 55	90 00	66 49- 68 47	. . .	28	“ “
h 110	24 42	90 00	24 16	90 00	23 01- 25 07	. . .	22	“ “
g $2\bar{1}0$	115 24	90 00	115 12	90 00	115 04-115 35	. . .	10	“ “
f 320	127 24	90 00	127 16	90 00	126 44-128 05	. . .	11	“ “
k $\bar{1}10$	143 38	90 00	143 50	90 00	143 27-144 13	. . .	3	poor
u 054	3 16	49 26	3 26	49 31	3 24- 3 28	48 42-50 20	2	fair
o 011	4 07	42 48	4 06	43 00	3 47- 4 20	42 34-43 45	8	very good
v 035	7 04	28 22	7 08	29 07	. . .	. . .	1	“ poor
w 025	10 59	19 13	11 03	19 25	10 45- 11 22	18 54-19 57	3	poor
s $0\bar{1}1$	176 15	45 29	175 51	45 29	175 23-176 17	45 03-45 44	10	very good
d 101	73 49	32 39	73 37	32 45	73 02- 73 56	32 40-32 54	8	“ “
x 305	77 20	22 04	76 56	22 00	. . .	. . .	1	fair
y 205	81 14	16 08	80 05	16 50	. . .	. . .	1	“
n $\bar{1}01$	−119 12	28 55	−119 08	28 44	118 20-119 31	28 33-28 52	6	“
p 111	28 11	52 29	28 19	52 27	28 15- 28 27	52 17-52 48	2	very good
t 112	31 44	32 56	31 20	33 17	. . .	. . .	1	poor
i $\bar{1}\bar{1}2$	−162 04	34 01	−165 03	34 37	. . .	. . .	1	“

crystals with small but plane faces giving angles agreeing closely with calculated positions.*

x (305) and y (205) were each observed but once as narrow faces between d and c, giving fair reflections and moderately close to calculated positions. They need confirmation.

u (054) was observed on two crystals as a narrow face between o and

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* In the figure of babingtonite in Dana (System, 1892, p. 382) a plane lettered n is shown corresponding to this form ($\bar{1}01$), which would be the pyramid ($\bar{2}21$) in Dana's position. No mention of this form is made in the text, nor is it found in the figure in Des Cloiseaux (Atlas, Pl. XII. Fig. 66), which is assigned as the source of Dana's drawing. Hintze (Mineralogie, II. p. 1169, Fig. 422) seems to have reproduced Dana's figure without correcting this apparent draughtsman's error.

b. It may be regarded as assured, although the values for the two observations differ rather widely.

w (025) was found on three crystals as a narrow face between o and c and may be regarded as established.

v (035) was observed but once as a faint line face between o and c. Its position is fairly good, but it needs confirmation.

Of the pyramids, p (111) was measured on two crystals and observed on several others. It is always a distinct face giving brilliant reflections, and is well established by the close agreement of measured and calculated angles.

t (112) and i ($\bar{1}\bar{1}2$) were each measured but once as narrow truncations of the edges between d and o and s and n respectively. The reflections were poor and the angular positions are not very close to calculated values, but their positions in the zones and the fact that each was observed several times, although with faces too narrow to give measurable reflections, seem to assure both of these forms.

The drawings, each presenting a plan and a clinographic projection of a crystal, illustrate the various habits of the Somerville babingtonite and especially the occurrence of the new forms. Figure 3 is a simple combination particularly characteristic of the larger crystals. Figures 4, 5, and 6 are as nearly as possible in the proportions of the crystals on which the various new forms were found. Figure 6, with the omission of the planes u, x, and w, would reproduce very well the appearance of the majority of the smaller crystals. Figure 7 is an ideal combination of all the forms here described, and is represented as terminated below by the perfect basal cleavage, which is very commonly developed. The gnomonic projection, Figure 1, also brings out well the relations of the forms.

Chemical Analysis.

The material for analysis was obtained from a single large pocket of prehnite in which the babingtonite was embedded in fine granular form. The whole mass was roughly hand-picked, and the babingtonite crushed and passed through a coarse sieve, washed to remove dust, and treated with dilute acid to remove traces of calcite present. It was quite free from limonite. It was then separated with an electro-magnet, which readily attracted the babingtonite, leaving behind the prehnite and almost all of the epidote, of which a very small quantity was present. After a second treatment under the magnet with a slightly less powerful field, the material was placed in methylene iodide at its maximum density, 3.34, in which the larger portion of the babingtonite slowly settled, leaving floating all fragments with adhering prehnite. About 3 grammes was thus obtained, which under the microscope showed no appreciable impurity.

The analysis, by Fraprie, was made according to the method of Hillebrand for silicate analysis, except that the manganese was precipitated with bromine water.

	Analysis.	Recalculated to 100% omitting H_2O.	Molecular Ratio.		
SiO_2	52.25	52.66	0.8777	0.8800	8.86
TiO_2	0.18	0.18	0.0023		
Al_2O_3	5.27	5.31	0.0521	0.0993	1.00
Fe_2O_3	7.49	7.55	0.0472		
FeO	11.05	11.14	0.1547	0.5630	5.67
MnO	1.94	1.96	0.0276		
CaO	20.36	20.52	0.3664		
MgO	0.46	0.46	0.0115		
$(K, Na)_2O$	0.22	0.22	0.0028		
Loss (H_2O)	0.29	. . .			
Total	99.51	100.00			

The analysis shows a babingtonite somewhat lower in manganese and much higher in aluminum than the average, but otherwise of normal character. It may be expressed by the formula,

$$(Ca,Fe,Mn)\ SiO_3 \cdot (Fe,Al)_2\ (SiO_3)_3$$

with the two molecules present in the proportion of about $5\frac{3}{4} : 1$.

2. Babingtonite from Athol, Mass.

Babingtonite was first reported from Athol by Shepard * in 1849, and the locality was cited for the mineral in his Mineralogy, 1857, p. 183.

J. D. Dana was the first to examine the crystals critically, and his measurements, made on very small crystals, were not conclusive, as they agreed but poorly with the angles of babingtonite from Arendal. His figure and measurements are to be found in his Mineralogy, 1854, p. 368, and the question of the identity of this mineral has remained unsettled. In Dana's System, 1892, reference is simply made to the description cited above, the matter being still left in doubt.

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* A. J. Sci., VIII. (1849), p. 275.